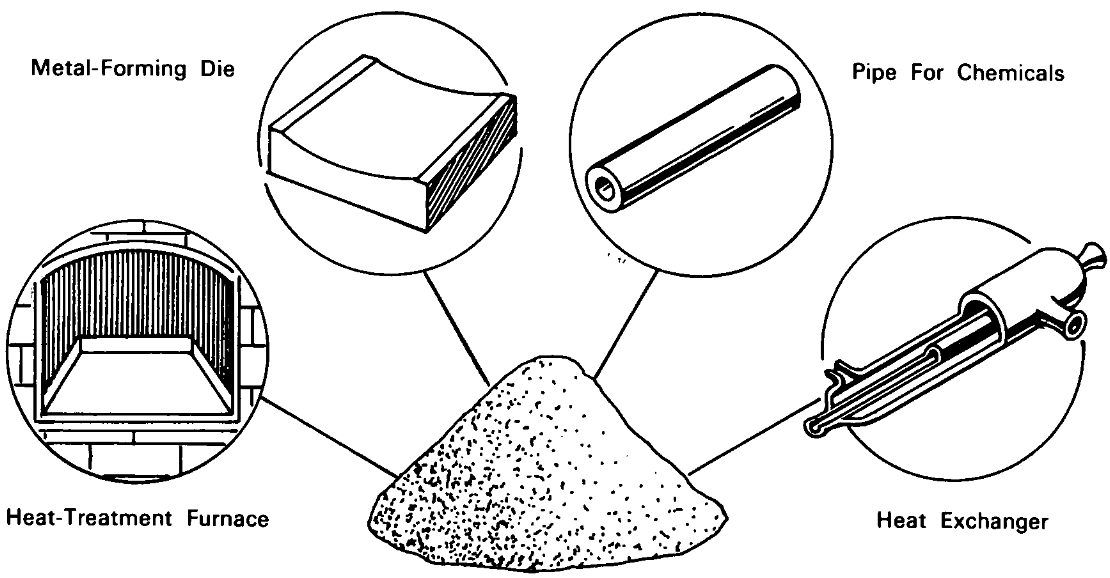
NASA TECH BRIEF

Refractory Ceramic Has Wide Usage, Low Fabrication Cost



The problem: A refractory material that can be formed into complex shapes at low cost is needed for numerous industrial applications where high temperature is a factor. Needs include molds for high-temperature brazing, investment casting, and dies for fabricating high temperature metals. In addition to characteristics such as heat resistance, the desired material must be suited to standard fabrication techniques.

The solution: A ceramic, fused amorphous silica that can be formed by slip casting. Previously, this ceramic has not been widely used due to cost and fabrication problems. Its industrial use has been accelerated by government-sponsored missile/space research which helped reduce its cost, as well as yielding data on its physical characteristics and fabrication techniques. It needs only a low temperature cure, exhibits good strength properties, and has been found satisfactory for many refractory needs. Because of its excellent characteristics as a thermal and electrical insulator, its resistance to chemicals, and the fact that it is little affected by extreme temperature changes, the ceramic appears to have wide application.

(continued overleaf)

How it's done: Particulate, fused amorphous silica, is cast in plaster molds having the shape of the part being fabricated, with no allowance for shrinkage necessary. Complex shapes can be attained with conventional ceramic forming techniques. High temperature firing is not required. The surface of the finished part is as good as the mold to about 40 microns RMS. Brazing fixtures for stainless steel honeycomb as large as 30 feet in one dimension have been successfully manufactured. A one-piece, double-wall heat exchanger of low neutron absorption cross section and uncooled reflectors for quartz lamps have been made with normal ceramic methods.

An outstanding characteristic of this ceramic is its resistance to thermal shock. It can be heated to about 2,000°F, and plunged into liquid nitrogen at -195°F without damage. Not only is thermal expansion low, 3 to 5 X 10^{-7} inches linear/°F, but thermal lag is exceptionally good.

Tests of the physical properties in space research have established that compression strength of several thousand pounds per square inch can be obtained without reinforcement. Fused amorphous silica may be controlled in normally cast pieces to obtain density of 125 lbs/cu ft, and foams of less than 25 lbs/cu ft have been made. By glazing with a plasma arc to obtain a high viscosity surface melt film, a gastight surface has been produced.

Notes:

1. Fused silica boiler combustion rings are reported to have given service life of several years in applications where normal refractory brick lasted only a few months.
2. Metal forming is an excellent application for fused amorphous silica. High temperature metals, such as type 420 stainless steel, titanium, and beryllium sheet can be simultaneously formed and heat-treated in dies made of this ceramic. Certain complicated shapes are almost impossible to make by other methods. Of interest, also, are short runs of extremely large areas of sheet aluminum by this technique. Sheet glass has also been formed and heat-treated in these dies. In high temperature brazing of honeycomb stainless steel panels, where the mold must not warp when subjected to heat at 2,000°F, only fused amorphous silica has been found satisfactory.
3. Reflectors for heaters employing quartz lamps have worked well in service tests. Because of the excellent heat properties of this ceramic, no cooling is needed for the reflectors.
4. Less costly heat exchangers are possible in certain applications. For example, heat exchangers for nuclear applications cost less than those made from clear fused silica. Fused amorphous silica is one of the few materials which is relatively unaffected by high energy neutrons.

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated.

Source: Marshall Space Flight Center (M-FS-67)